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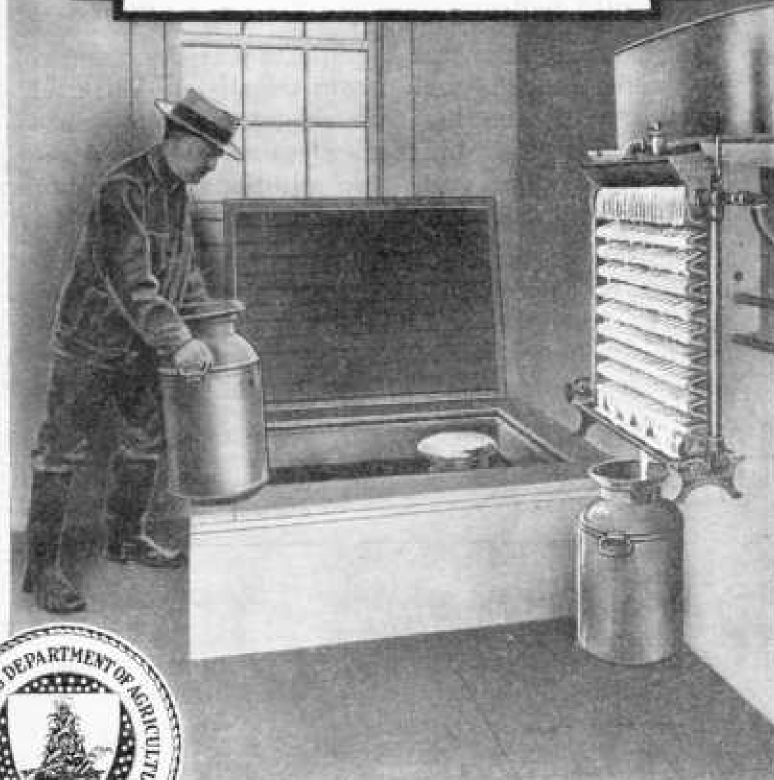
COOLING MILK & CREAM ON THE FARM



DAIRYMEN LOSE THOUSANDS of dollars annually because of poorly cooled milk and cream. These losses occur because the milk or cream is returned by dealers to the farmers, and because of low-grade manufactured products which bring low prices.

Every dairyman who produces and delivers a high grade of milk or cream raises the average quality of all the milk and cream with which it is pooled, and as a result a better product reaches the consumer.

Proper cooling is just as important with cream as with milk, especially as cream usually is delivered less frequently and therefore has greater opportunity to undergo undesirable fermentations. Proper cooling is easily done with little additional equipment and labor.

Natural ice can be had on the dairy farms that produce 85 per cent of this country's milk and cream supply. Even where ice is not available, milk and cream, by better use of available cooling facilities, may be cooled more effectively than at present.

Washington, D. C. Issued May, 1918; revised October, 1922

COOLING MILK AND CREAM ON THE FARM.

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Market Milk Specialist, Dairy Division, Bureau of Animal Industry.

CONTENTS.

NECESSITY FOR PROMPT COOLING.

COOLING MILK AND CREAM on the farm promptly and properly would prevent to a very great extent the enormous waste which occurs every year. Milk dealers and manufacturers of dairy products often are obliged to return to the farmer any milk or cream that is sour or about to become

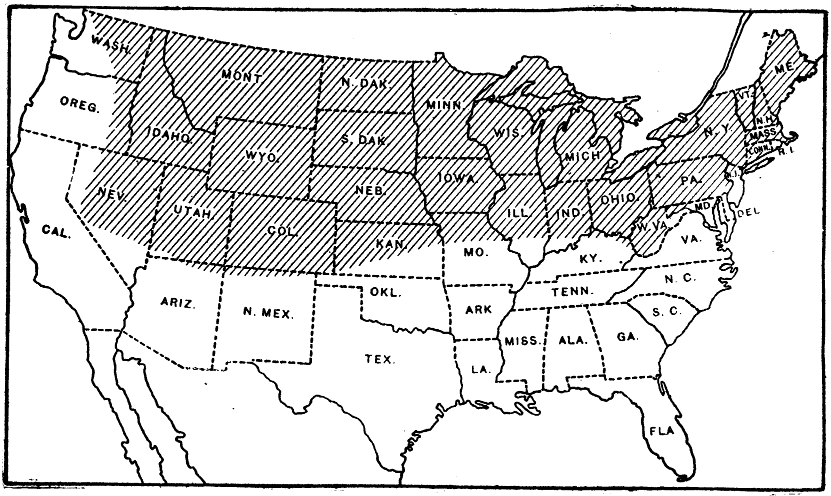


FIG. 1.—Map of the United States, showing region of natural ice. More than 85 per cent of the milk and cream sold from farms in this country is produced in the shaded area.

sour. Part of the returned milk is fed to live stock, and frequently the remainder is a total loss. In addition some of the cream that is accepted by creameries is in poor condition and can not be manufactured into the best grades of butter.

More than 85 per cent of all the milk and cream sold from farms in the United States is produced in sections where natural ice can be had for the harvesting. (Fig. 1.) Therefore with the proper use of ice at least 85 per cent of the milk and cream can be cooled on the farm to a temperature so low that they will reach the dealer and the consumer in good condition. To bring about a general improvement of the milk and cream supply it must be cooled promptly and efficiently every day. The most advantageous use of the cooling

[1] Mr. Gamble resigned August 31, 1918.

facilities which are available on every farm would result in great improvement in the quality of milk and cream and at little if any additional cost.

DEVELOPMENT OF BACTERIA IN MILK.

Milk as it leaves the udder of the healthy cow contains only a few bacteria, but others are added by careless handling and improper methods. Bacteria multiply rapidly in warm milk and soon cause souring or other undesirable fermentation. No matter how clean and healthy the cows or how sanitary the methods or how clean the utensils, milk will soon deteriorate in quality and contain many thousands of bacteria if it is not effectively cooled. Bacteria may get into milk from the stable air, but by far the greater number come from unclean

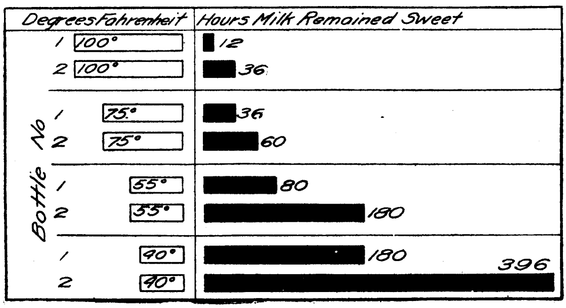


FIG. 2.—Diagram showing time required to sour milk of high (1) and low (2) bacterial content at different temperatures.

and unsterilized utensils and the dust and dirt that fall from the flanks and udder of the cow during milking. Even though produced under the best of conditions, milk just drawn always contains a few bacteria.

Bacteria grow and multiply much more slowly in cold than in warm milk. When drawn from the cow milk has a temperature a little above 90° F., a temperature at which bacteria grow very rapidly. The effect of temperature upon the development of bacteria is well illustrated by two samples of milk, one of which had 280,000 and the other 16,400 bacteria per cubic centimeter[1] at the beginning. Each sample was divided into 4 parts, and the 8 parts were set away at certain temperatures to determine what length of time would elapse before the milk soured. (Fig. 2.) The high-bacteria sample set at a temperature of 100° F. soured in 12 hours, while the low-bacteria sample at the same temperature kept sweet 36 hours. When kept at 40° F. the high-bacteria sample soured in 180 hours, while the low-bacteria sample soured in 396 hours. The high-bacteria sample represented milk of ordinary quality, while that containing the smaller number was representative of milk of a higher quality. The effect

[1] A cubic centimeter equals about 16 drops of water.

of low temperature in checking bacterial growth and multiplication is very evident.

If cooling is delayed bacteria may develop rapidly and be present in large numbers, even though the milk is eventually cooled to a low temperature. On dairy farms where only a few men are employed, milk is often kept in the barn for an hour or more before being cooled. Under such conditions it may be several hours after the milk is drawn before it is cold enough to check the growth of bacteria. This condition is especially true when the water used for cooling is at a temperature of 55° F. or higher and ice is not used. Cooling should be begun immediately after the milk is drawn from the cow if best results are to be obtained. Prompt cooling necessitates the immediate removal of milk from the barn to the place of cooling, which also is good practice because it shortens the time that the milk is exposed to the air of the barn. Since, in general, bacteria multiply more slowly as the temperature is lowered, the more rapid the drop in temperature the less time for their multiplication and growth.

As now distributed, milk is from a few to as high as 72 hours old before it reaches the consumer. There is, therefore, plenty of time for the growth and development of bacteria if conditions favor them. Milk that has not been cooled promptly spoils very quickly when warmed, as frequently happens in hot weather during transit from the farm to the city. It is not uncommon also for the temperature of milk to rise 10 degrees between the time it is delivered to the consumer and the time it is placed in the ice box.

While cleanliness is the first essential in the production of milk, prompt cooling and storage at low temperatures are the most important factors in preventing souring. For best results, then, milk should be cooled immediately after milking and kept at a temperature low enough to check the growth of bacteria. Cream, likewise, should be cooled immediately after separation and be kept cold until used.

THE PRINCIPLE OF COOLING.

Proper cooling of milk is easily accomplished. Water, perhaps the most common cooling agent, has been used for the purpose for centuries. When a can of warm milk is placed in cold water the heat passes into the water until the temperature of the two is about the same. The final temperature of both depends largely upon the relative volume and initial temperature of each. If a 10-gallon can of milk at a temperature of 85° F. is placed in a cooling tank containing 30 gallons of water at 37° F., the final temperature of both milk and water under average summer conditions will be about 50° F. (Fig. 3.) With twice the volume (or 60 gallons) of water, the final temperature of the milk and of the water will be about 45° F. It is evident, therefore, that in order to cool milk to below 50° F. it is

around the outer edge of the bottom, through which the milk flows over the cooler. After passing over the corrugations the milk is caught in a trough at the bottom, through which it flows into the receiving can.

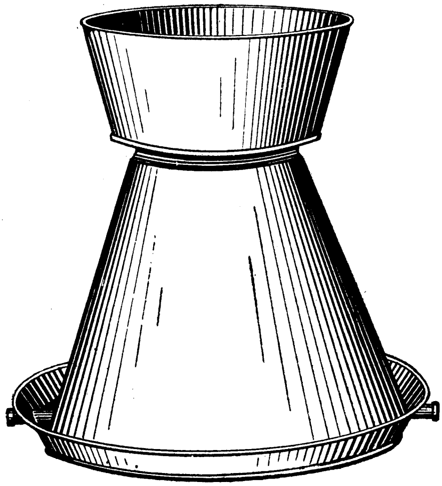


FIG. 4.—Cone milk cooler for water and ice. To obtain good results with this cooler the water and ice must be stirred frequently.

Another type of cooler is shown in figure 6. In this apparatus, also, cold water enters near the bottom, flows upward and out near the top, while the warm milk flows over both sides of the corrugation and is caught by a trough at the bottom, from which it passes to the receiving can.

MILK-COOLING TANKS.

To cool efficiently and hold milk at low temperatures a properly constructed cooling tank is necessary in addition to a surface cooler. The object of the cooling tank is to complete the cooling and keep the milk cold. A well-constructed tank also helps protect the milk from flies and other insects, dust, foul odors, and other impurities, and if well insulated also protects milk from freezing in the winter.

CONSTRUCTION.

A cooling tank that is durable and easily cleaned is easy to construct. It should be so built as to prevent so far as possible the loss in cooling effect through radiation. The depth of the tank depends upon the height of the milk cans. Provision should be made so that the water will always be as high on the outside of the can as the milk is on the inside. An adjustable overflow pipe should be provided to regulate the height of the water in the tank; otherwise the milk in that part of the can extending above the water line will not cool so rapidly as the milk below the water level. Thus the time taken to cool the can of milk is increased in proportion to the quantity of milk above the water line. No matter what type of tank is

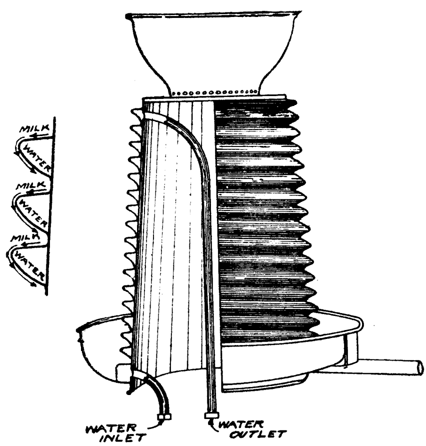


FIG. 5.—Spiral milk cooler for running water.

used, it should have a drainage outlet in the bottom so that when cleaning is necessary the water may be drawn off. Many milk-cooling tanks in use are without such outlets, and, being hard to empty, are seldom cleaned. The tank should be kept clean and the water in it should be fresh and pure. In its bottom there should be some narrow strips on which to set the milk cans in order that the water may flow not only around but also under them. When a concrete tank is used it is desirable to place boards or strips of iron on the edges of the tank to prevent chipping the top edges of the concrete as the cans are lifted in or out.

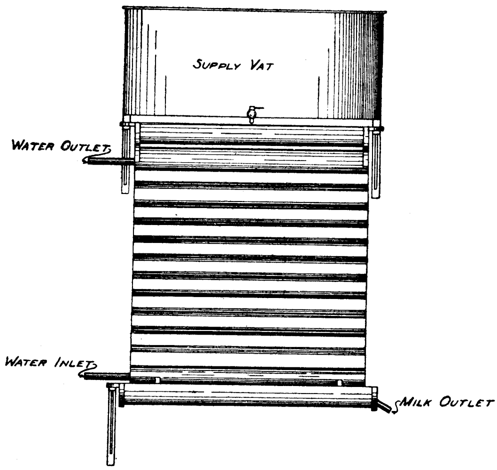
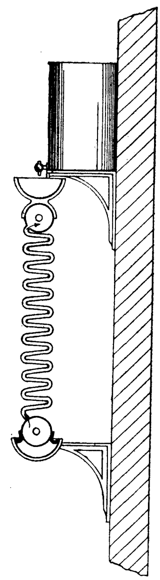


FIG. 6.—Corrugated milk cooler for running water.



SIZE OF TANK.

The size of the cooling tank depends upon the quantity of milk to be cooled. Milk tanks are often too large to cool efficiently the quantity of milk produced without wasting ice. In many cases, on the other hand, they are too small to permit the use of ice enough to cool the milk properly after the cans are placed in the tank. Half-barrels are sometimes used as tanks, but are not suitable for the proper cooling of milk in 8-gallon or larger cans. When such a can is placed in a half barrel with water there is not room for ice enough to cool and hold the milk at 50° F. Figure 7 shows graphically the quantity of ice necessary to cool a 10-gallon can of warm milk to 50° F. and hold it at that temperature for 24 hours under ordinary summer conditions.

Because the quantity of milk produced on the farm varies from year to year and from season to season, the milk-cooling tank at times may be either too large or too small. To overcome the difficulty

it is advisable, when building, to divide the tank into two parts, the larger having about twice the capacity of the smaller. The tank of course should be so large that when so divided the larger part will hold a quantity of water sufficient to cool the ordinary production of milk. The additional space is then available if the production should increase, or the smaller compartment may be used in case less milk is produced. In building, such arrangements can be made with but little additional cost.

The necessity for a cooling tank of proper size is seen in the following 4 examples: (1) In a plain concrete tank containing 120 gallons of water at a temperature of 54° F. and a 100-pound block of ice, the temperature of a 10-gallon can of milk at 91° was 53½° F. at the end of 9 hours. This tank was divided into two compartments, one being two-thirds and the other one-third of the capacity of the original tank. (2) When 42 gallons of water at 54° F. and a 100-pound block of ice were put into the smaller part of the tank, a 10-gallon can of milk at 91° F. was cooled to 48° F. in 9 hours, or 5½ degrees lower. (3) In a wooden tank containing 120 gallons of water at 54° F. with 100 pounds of ice a 10-gallon can of milk at 91° F. was cooled to 50° F. in 9 hours. (4) When this tank was partitioned somewhat like the concrete tank, 42 gallons of water at 54° F. and 100 pounds of ice cooled a 10-gallon can of milk from 91° F. to 41° F. in 9 hours.

FIG. 7.—Quantity of ice necessary to cool a 10-gallon can of warm milk to 50° F. in a half barrel of water, and to hold it at that temperature for 24 hours.

These examples show that a tank holding a little more than 4 gallons of water for each gallon of milk is more efficient than a larger one when precooling is not practiced. Lower temperatures can be obtained and ice can be used more effectively in wooden tanks than in plain concrete tanks. Insulated tanks of either concrete or wood are still more efficient.

LOCATION OF TANK.

The milk-cooling tank should be placed in the milk house where it will be protected from the sun in summer and from excessive cold

in winter. Tanks placed outdoors lose much of their cooling effect through radiation and they also deteriorate rapidly. On many farms the milk tank, like the farm pump, is exposed to the weather. When ice is so exposed in tanks, especially if of galvanized iron or uninsulated concrete, the losses through radiation during hot weather are very great.

USE OF ICE IN TANKS.

Preparation for cooling milk should begin before milking. For best results ice should be put into the cooling tank long enough before milking so that the tank water will be at a low temperature when the milk is ready to be cooled. The quantity of ice necessary for the proper cooling of milk produced on any farm can be determined best by putting a definite weight of ice into the cooling tank and ascertaining, by means of a dairy thermometer, how much is necessary to cool to and keep milk at 50° F. or below. In general, it depends upon how much milk is to be cooled, the size and construction of the tank, its location, and the season of the year.

When milk is first precooled over a surface cooler with water at temperatures of 50, 55, or 60° F., and the water in the cooling tank is at a temperature of 45° F. when the milk is placed in the tank, about $1\frac{1}{2}$, 2, or $2\frac{1}{2}$ pounds of ice will be required, respectively, to cool and hold each gallon of milk at 50° F. On the other hand, without precooling, the water in the tank must be cooled down to 45° F. and then about 4 pounds of ice added for each gallon of warm milk to be cooled. In other words, practically double the quantity of ice is required when milk is not precooled.

EFFICIENCY OF DIFFERENT COOLING TANKS.

On about 80 per cent of the farms that produce market milk in the United States some kind of tank is used for cooling milk. A survey of many thousand dairies showed that about 20 per cent of the cooling tanks were of metal, 25 per cent of wood, and 30 per cent of concrete, the remainder being of miscellaneous materials. Very few tanks in use are insulated, and in very few cases is provision made to minimize the loss of cooling due to radiation. Where running water and plenty of ice are available it may be unnecessary to insulate the tank. Usually, however, the saving of ice and the greater cooling effect obtained by means of insulation justify the additional expense.

The relative loss of cooling effect in different kinds of tanks expressed in pounds of ice melted is shown in the table on page 12.

The economy of an insulated tank and the importance of covering and shelter are very evident. The galvanized-iron tank, without cover and exposed to the sun, showed a loss of 168 pounds of ice compared with only 7.6 pounds for the cork-insulated wooden tank

Quantities of ice which melted in 9 hours in each of 4 types of milk-cooling tanks under various conditions of exposure, when average outside air temperature was 84.2° F.

Type of tank.	Tanks, without covers, exposed to sun.	Tanks, covered, exposed to sun.	Tanks, without covers, in milk house.	Tanks, covered, in milk house.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Galvanized-iron tank	168	111	107	84
Plain concrete tank	137	88	80	61
Wooden tank	107	38	50	30.5
Cork-insulated wooden tank	80	12	30	7.6

properly covered and placed in the milk house. The difference between these two extremes amounts to at least 320 pounds of ice a day, or 24 tons in 150 days. At the moderate price of 15 cents a hundredweight the ice that must be harvested, stored, handled, and housed unnecessarily each season would amount to $72. In fact the saving by the use of a well-insulated tank properly covered and protected would soon pay for any difference in the original cost.

HOW TO BUILD AN INSULATED TANK.

While, from the point of view of cooling, wooden tanks give good results, an insulated concrete tank is much more desirable, as it is easily built and can be set partly in the ground. A wooden or a galvanized-iron tank does not last long under similar conditions. When the tank is set low, cans of milk can be lifted in or out with much less effort than when it is entirely above the ground. The total thickness of the walls of an insulated concrete tank should be 8 inches, divided into two walls, the outside being 2 inches, then 2 inches of good insulation and the inside wall 4 inches thick. The concrete mix should consist of 1 part Portland cement, 2 parts clean, sharp sand, and 4 parts broken stone or gravel. For the purpose of waterproofing, hydrated lime equal to 10 per cent by weight of the cement should be added to the mixture. The insulation used should be coated with and set in hot asphalt which should be allowed to become thoroughly dry before the inner walls of the tank are put up. The inside walls should be very carefully troweled so as to insure a smooth surface without projecting particles.

USE OF WELL OR SPRING WATER FOR COOLING MILK.

An arrangement for cooling milk either with or without ice is shown in figure 8. If ice can not be had, special care should be taken to use the water at as low a temperature as possible. The water from the well may be pumped directly to the surface cooler and the milk-cooling tank. Water from the storage tank should be used only during very cold weather, when its temperature is colder than that pumped direct from the well. When ice is not available, water pumped for the use of horses and other live stock should first flow

through the milk-cooling tank. The inlet should be placed at the bottom so that the water flows in and around the milk cans and then out at the overflow near the top into the stock tank. When ice or running water can not be obtained, the milk-cooling tank should hold from 6 to 10 gallons of water for each gallon of milk to be cooled and stored, and the water in the tank should be changed frequently.

On many farms milk is cooled in springs or in tanks fed by springs. Water of that kind is seldom cold enough to cool milk promptly to 50° F. in hot weather. Unless the spring is protected from the direct rays of the sun and from surface drainage, the temperature of the water is raised several degrees before it reaches the cooling tank. Spring water always should be carried to the cooling tank in a pipe laid several feet under ground. Instances have been known in which spring water has been warmed 20 degrees

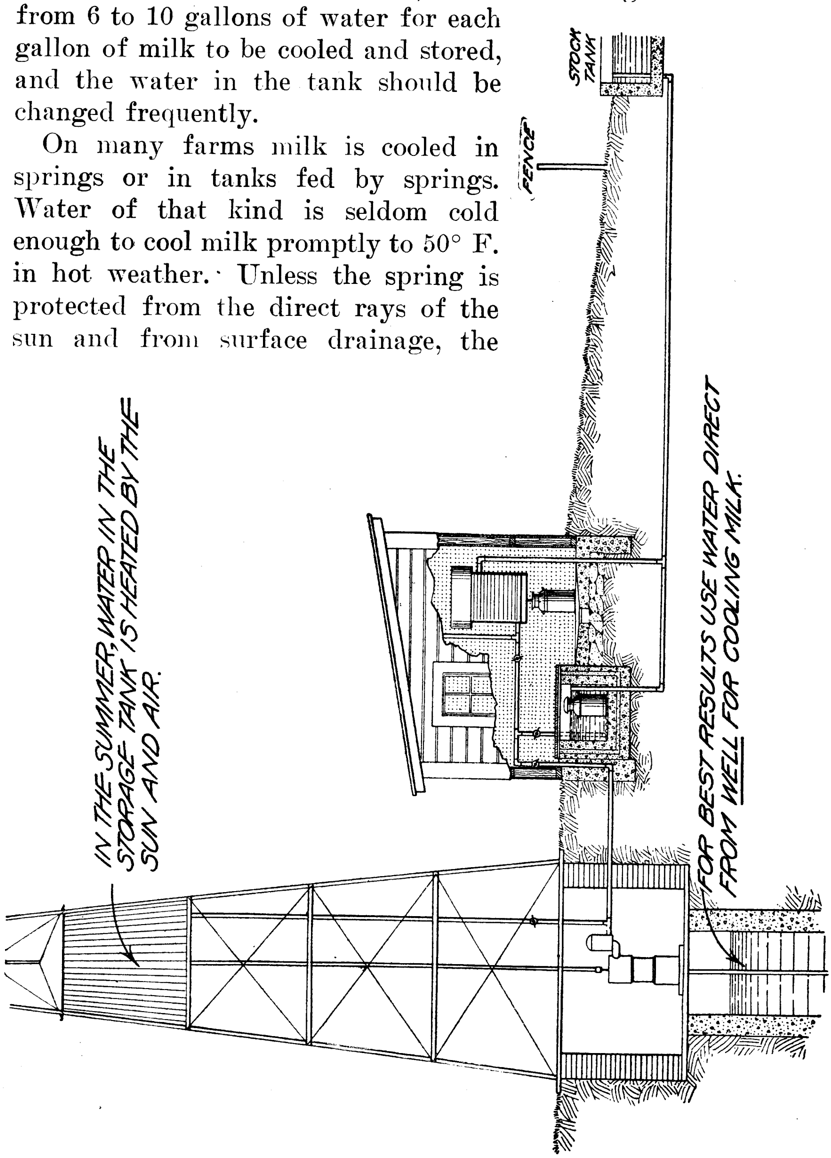


FIG. 8.—Arrangement of water supply for milk house.

in flowing from the spring to the milk tank, whereas when properly conveyed its temperature should rise only a few degrees.

Spring water is seldom as cold as it is thought to be, and springs that are said to be "as cold as ice" frequently have a temperature as high as 65° F. An accurate thermometer is essential, therefore, to determine the temperature of the water for cooling milk.

KEEPING MILK COLD DURING SHIPMENT.

In order to be kept sweet, milk in transit should be protected from high temperatures. A large percentage of the milk supply for cities is delivered at the railroad station by producers, although some is hauled direct to the city. Even under the best conditions milk that is transported during hot weather is usually several degrees warmer by the time it reaches the railroad station. On the railroad it is held from a few hours to all day, and unless shipped in cars especially equipped to maintain low temperatures there is a further rise in temperature. That is the case when milk is shipped in baggage cars or in milk cars unprovided with ice. To make sure that milk reaches the city consumer in the very best condition it should not only be promptly cooled to 50° F. or below on the farm, but also should be protected during shipment. Precautions that prevent milk from becoming warmer during the summer also protect it from freezing during excessive cold in the winter. In the latest types of refrigerator cars milk is maintained at temperatures of about 40° F. when precooled to about that temperature before shipping in carload lots. If the cars are opened at several stations to receive milk it is more difficult to maintain a low temperature.

SPECIAL CANS AND JACKETS.

To illustrate the importance of protecting milk in transit during hot weather, four 10-gallon cans of milk cooled to 44° F. were hauled a distance of 13 miles from a farm to the railroad station. No. 1 was an insulated can, No. 2 was an ordinary unprotected can covered with a one-inch felt jacket, No. 3 was covered with a half-inch felt jacket, and No. 4 was an ordinary unprotected can. During the trip the milk in the insulated can rose 1 degree, the milk in the cans protected with jackets rose 6 degrees, and the milk in the unprotected can rose 20 degrees. The cans were then shipped by rail in an ordinary baggage car for more than 1,000 miles at an average air temperature of about 80° F., in order to study the effect on the milk. In the unprotected can the milk had reached a temperature of 60° F. when it

had traveled about 10 miles from the farm (before reaching the railroad), the milk in the can covered with the half-inch jacket reached 60° F. after about 268 miles of travel, the can covered with the one-inch jacket traveled about 332 miles before reaching 60° F., and the milk in the insulated can did not reach 60° F. until after 650 miles of travel. By the use of a half-inch jacket it was possible to ship an individual can of milk 26 times as far as in the ordinary can before the temperature rose to 60° F.; the one-inch jacket increased the shipping distance 33 times, and the insulated can 65 times that of the ordinary can.

Milk sours very rapidly at temperatures above 60° F. and therefore should be kept below that temperature and preferably below 50° F. until used.

HOW TO STOP MILK LOSSES.

A survey of the temperature at which milk is received at railroad stations for shipment to market during the hot months showed the average temperature of morning's milk to be about 60° F., and in some cases it was as high as 80° F. These temperatures are much too high to permit milk to be shipped a considerable distance without souring. Milk produced the evening before showed an average temperature of about 5 degrees lower than morning's milk, and in some cases was as low as 40° F. A large part of the annual loss from sour milk is due to the shipping of milk at too high a temperature.

The use of a surface cooler is especially necessary when the time between milking and shipping is short. If warm milk is run over a surface cooler and then set in a tank of water cooled with ice to 40° F. or below, it should not be difficult to cool milk to 50° F. within an hour after it leaves the cow. The fact that precooling with a surface cooler is not practiced, and that ice is not put into the cooling tank until after the milk is put there, is the cause of much milk reaching the shipping station in summer at so high a temperature that it sours on the way to the city.

On many farms the water used for cooling milk comes from the general storage tank or from a spring which flows on the surface of the ground. Under such conditions the temperature of the water when it reaches the cooling tank is much higher than when it leaves the well or the spring. Well or spring water that has a temperature of from 50° to 55° F. frequently is warmed up to 70° or 75° F. before it reaches the cooling tank. Under such conditions more ice and a longer time are necessary for cooling. When milk is not precooled and ice not added to the tank until after the milk is placed in it, with the water supply at 70°, 60°, 55°, or 50° F., the time needed to

cool 10 gallons of milk to 50° F. is, respectively, about 2 hours and 25 minutes, 1 hour and 45 minutes, 1 hour and 30 minutes, and 1 hour and 20 minutes. The time required to cool milk to 50° F. by such methods is too long, especially when morning's milk must be delivered at the railroad station within a short time after milking.

The effect of not putting ice into the cooling tank until after the milk is placed there is strikingly shown. When 10-gallon lots of milk, after having been precooled with water at 70°, 60°, 55°, and 50° F., were placed in water at the same respective temperatures and ice then added to the tank, it required 2 hours and 10 minutes, 1 hour and 15 minutes, 43 minutes, and 20 minutes, respectively, to cool the lots to 50° F. The precooling, with a surface cooler, of a 10-gallon can of milk with water at 70° F. saved approximately 11 pounds of ice; with water at 60° F., 16 pounds of ice were saved; with water at 55° F., 19 pounds of ice were saved; and with water at 50° F., 22 pounds of ice were saved.

The best and quickest way to cool milk to 50° F. is to cool it over a surface cooler with the coldest available water and then set the cans of milk in a well-insulated tank the water of which is below 40° F. A 10-gallon can of warm milk precooled with water at 55° F. and set in a tank of ice water at 37° F. was cooled to 50° F. in 20 minutes.

THE COOLING OF CREAM.

In general the cooling rules laid down for milk may be applied to cream with equally good results. There are, however, some additional considerations. Cream, which contains more butterfat and less milk sugar, sours more slowly than milk. Thick or rich cream does not sour so quickly as thin cream; therefore milk should be separated so as to produce 30 to 35 per cent cream. Such cream sours more slowly and makes less bulk to handle and transport, besides leaving more skim milk on the farm.

Cream should be cooled immediately after it is separated. This may be done by precooling over a small surface cooler and then setting the can in ice water; or, if only a small quantity is handled, it may be put into tall cylindrical cans, called "shotgun" cans, which can be placed in ice water. Fresh cream should not be mixed with previous skimmings until it has been thoroughly cooled, as the addition of warm cream to cold hastens souring by warming up the whole mass. As cream cools more slowly than milk, it is very important to use ice to the best advantage.

Do not forget that the separator parts should be washed and sterilized *after each use.*

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